Optical Engineering

SPIEDigitalLibrary.org/oe

Ultrashort Pulsed Laser and Applications Engineering

Marcos Dantus
Gerald C. Manke, II

SPIE

Ultrashort Pulsed Laser and Applications Engineering

Marcos Dantus
Michigan State University
Department of Chemistry
East Lansing, Michigan 48824-1322
E-mail: dantus@msu.edu

Gerald C. Manke II
Naval Surface Warfare Center—Crane
300 Highway 361
Crane, Indiana 47522
E-mail: Gerald.manke@navy.mil

Forty years after the publication from Shank and Ippen on the generation of subpicosecond laser pulses we are witnessing an explosion in the number of applications for ultrashort pulsed lasers (USPL).[1] While some technologies are invented and applied in industry without delay, there has been a significant delay in the deployment of femtosecond lasers. Ultrashort pulsed lasers used to require a laboratory environment and in many cases included flowing laser dye solutions that made them extremely impractical. The development of chirped pulse amplification for solid state and fiber lasers[2,3] has changed the landscape and has made available intense USPL sources that can be operated outside the laboratory. This in turn has opened numerous applications in the materials processing and medical devices markets. In this special section we present a collection of papers that is representative of some of the advancements and applications in USPL design and applications.

The development of commercial sources has enabled advanced manufacturing techniques that improve products and materials processing, led to advances in biomedical device fabrication and research, and even USPL-unique measurements and diagnostic methods. In the realm of basic research, ultrashort pulsed lasers have revolutionized our knowledge of the nature of chemical reactivity and molecular dynamics[4]—a subject that earned Professor Ahmed H. Zewail the Nobel Prize in Chemistry in 1999.[5] Ultrafast lasers have also been implicated in the Nobel Prize to Professors Theodor W. Hansch and John L. Hall on the development of frequency combs and their use for ultraprecise metrology.[6]

The articles in this special section can be separated into four categories. First, two of them cover the fundamental aspects on the interaction of USPL and matter: "Plasma enhancement of femtosecond laser-induced electromagnetic pulses at metal and dielectric surfaces," by S. Varma et al., and "Interaction of near-infrared femtosecond laser pulses with biological materials in water," by S.Varma et al.

Five papers discuss USPL sources and new concepts to make USPL more practical: "High-energy femtosecond 2-μm fiber laser," by P. Wan et al., "Energy scaling of Yb fiber oscillator producing clusters of femtosecond pulses," by B. Nie et al., "Concepts, performance review, and prospects of table-top few-cycle optical parametric chirped pulse amplification," by A. Vaupel et al., "Stretching and compressing of short laser pulses by chirped volume Bragg gratings: analytic and numerical modeling," by S. Kaim et al., and "Volume chirped Bragg gratings: monolithic components for stretching and compression of ultrashort laser pulses," by L. Glebov et al.

Two papers discuss methods for metrology, measurement, compression and characterization of USPL sources: "Real-time single-shot measurement and correction of pulse phase and amplitude for ultrafast lasers," by D. Pestov et al., and "Characteristics of an adjacent pulse repetition interval length as a scale for length," by D. Wei and M. Aketagawa.

Five papers present applications of USPL: "Imaging embryonic development with ultrashort pulse microscopy," by H. Gibbs et al., "Micro-hole drilling and cutting using a femtosecond fiber laser," by H. Huang et al., "Internal modification for cutting transparent glass using femtosecond Bessel beams," by W-J. Tsai et al., and "Ultrafast reflection and secondary ablation in laser processing of transparent dielectrics with ultrashort pulses," by M. Sun et al, and "Electric field measurements during filament-guided discharge," by A. Schmitt-Sody et al.

The collection of articles comprises a fascinating cross section of ultrashort pulsed laser applications and sources.

Disclaimer

The opinions, interpretations, conclusions and recommendations are those of the author and are not to be interpreted as representing the official views or policies, either expressed or implied, of the Department of Defense. Approved for Public Release, Distribution Unlimited.

References

1. C. V. Shank and E. P. Ippen, "Subpicosecond kilowatt pulses from a mode-locked cw dye laser," *Appl. Phys. Lett.* **24**(8), 373–375 (1974).
2. D. Strickland and G. Mourou, "Compression of amplified chirped optical pulses," *Opt. Commun.* **55**(6), 447–449 (1985).
3. A. Galvanauskas, "Mode-scalable fiber-based chirped pulse amplification systems," *IEEE J. Sel. Top. Quantum Electron.* **7**(4), 504–517 (2001).
4. M. Dantus, M. J. Rosker, and A. H. Zewail, "Real-time femtosecond probing of 'transition-states' in chemical reactions," *J. Chem. Phys.* **87**(4), 2395–2397 (1987).
5. A. H. Zewail, "Femtochemistry: atomic scale dynamics of the chemical bond using ultrafast lasers (Nobel lecture)," *Angewandte Chemie International Edition* **39**(15), 2586–2631 (2000).

6. J. L. Hall, "Nobel Lecture: defining and measuring optical frequencies," *Rev. Mod. Phys.* **78**(4), 1279–1295 (2006).

Marcos Dantus is a professor at Michigan State University in the Department of Chemistry; he is also the founder and Chairman of Biophotonic Solutions Inc. He pioneered the use of shaped ultrafast pulses as photonic reagents to probe molecular properties, control chemical reactions, and for practical applications such as biomedical imaging, proteomics, and standoff detection of explosives. His development of automated laser pulse compression is enabling fundamental research worldwide.

Gerald C. Manke II is the chief scientist for ultrashort pulsed lasers at the Naval Surface Warfare Center in Crane, Indiana. He earned a BA in chemistry from Wartburg College in Waverly, Iowa, in 1992, and a PhD in physical chemistry from Kansas State University in 1997. His primary focus is the use of laser technology for IR and RF countermeasures and other electronic warfare applications.